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First Expert Group Meeting on Computerized Maintenance Systems in Metallurgy *

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SOME SPECIAL ISSUES OF DESIGNING COMPUTER-AIDED MANAGEMENT INFORMATION SYSTEM FOR STEEL WORKS MAINTENANCE SERVICE **

Prepared by

A. Kagramanov ***

* Organized by the United Nations Industrial Development Organization (UNIDO) in co-operation with the Institute for Automation and Industrial Management (INORGA-Prague) under the auspices of the Czechoslovakian Ministry of Metallurgy and Heavy Engineering.

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*** GKES (State Committee for External Economic Relations, USSR

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1. Introduction

Automation and computer control of steel works maintenance service is a problem of almost the same importance and actuality as manufacturing process control itself. This can be concluded only from the fact that considerable reduction of opeeating facilities emergency shutdowns is anticipated through Computerized Maintenance Management Systems /CMMS/ implementation. For example, at Eastslovakian Steelworks /VSŽ, Košice, CSSR/ this innovation resulted in half decrease of downtime.

VSŽ scored big successes in the development of computer-aided management information system for steelworks maintenance service. Examination of this system by the team of Sovie professionals showed economic advisability of implementation of such systems in the USSR. Czechoslovakian recomendations on this topic are highly valuable for Soviet counterparts.

The USSR also obtained some experience of computerized problem solving for management of the maintenance operations, and this experience permits making a conclusion that supply with standard spare parts /subassemblies for operating facilities/ is the most critical problem to be considered first of all. This paper describes the problem in detail.

2. Special Features of Maintenance Process Control in Terms of Equipment Standard Components

Controlled plant of CMMS includes the following units:

1/ all enterprise equipment to be maintained,
2/ all repair shops which manufacture and recover spare parts,
3/ all warehouses which store spare parts inventories and materials required for maintenance processes.

One peculiarity of CMMS stems from its comprehensive nature since units under repair can appear to be mechanical equipment as well as electrical and power facilities.

Such comprehensiveness might lead one to low spirits provided one forgets that common rules exist for maintaining all types of operating facilities. Therefore, software of CMMS is universal as programs are independent of controlled unity type. All differences are defined by a behavior of any certain element whether it is mechanical, electrical or power-supplied, and dissimilarity in behavior produces different management rules.

2.1 Classification of Equipment Components

To expose the above mentioned differences of equipment components may be classified as follows:

1/ Replaceable versus unreplaceable - depending on whether or not a component is replaced when repaired.

Basically, replaceable components include large subassemblies which should be treated as an integral part of mechanical construction to be repaired in-place using different materials.

A replaceable component may be substituted by a similar one which previously existed as a stand-alone unit and was treated as a spare part of a production equipment.

2/ Recoverable versus unrecoverable - depending on whether or not a component becomes operational again after the repair.

A recoverable component when repaired after a wear-out or a failure can perform its functions within a production unit of equipment as before if proper recovery operations are carried out.

Unrecoverable failed component must be removed from a production equipment since its functionality cannot be recocered.

Unreplaceable component, obviously, must be recoverable, otherwise the production equipment unit would fail as a system after a failure of a single component. Replaceable components can be both recoverable and unrecoverable. Increase in a percentage of former ones improves economic figures of the production equipment performance.

3/ Standard versus nonstandard - depending on the range of usage as applied only to replaceable components.

A dedicated nonstandard component may serve as a spare part for a single production equipment only. It is constructed exclusively in connection with a given equipment, manufactured originally together with this one, and then produced repeatedly for supporting its recovery.

Standard components have a wider range of usage, for they can serve as spare parts of several equipment items. Their universality is defined by availability of different type components with different characteristics.

Designing and manufacturing of standard components are not associated with the development and manufacture of equipment units where standard components are used as spare parts. On the contrary, the last ones become building blocks of the former ones if required types of standard components are available.

Fig. 1 shows a classification tree for equipment components together with symbolic notation of different categories of replaceable components /spare parts/. This notation is used in a scheme of component movement route /see Fig. 2/. A colored symbol means operational unit, an uncolored one corresponds to a failed unit.

2.2 Behavioral Peculiarities of Equipment Standard Components

Analysis of various categories of equipment components on a behavioral level allows to expose some important peculiarities in terms of choice and statement of control problems for a maintenance management.

1/ Inventory management problems for standard and nonstandard components.

The wider a range of usage of a given type spare part, the more its required quantity and the better opportunities exist to control its inventory level. Standard spare parts batch manufacture by specialized factories expands these opportunities.

The multiple usage of standard spare parts involves availability of a special function within maintenance process control system connected with spare parts inventory allocation to users /denoted as "Al." on the Fig. 2/. Since standard spare parts may be used for different repair operations /on different equipment items/ they must be issued from stocks in accordance with their priority and a specified completion date.

As with nonstandard spare parts, they are of individual nature and so a flow of components is meaningless. It is possible to manufacture them only on user demand. The stocking of such components is unjustified and their manufacturing must be planned in connection with proper repair operations.

2/ Problems of reporting and analysis of equipment state are different for nonstandard and standard components.

For a total maintenance process a matter of great difficulty is the acquisition of data sufficient for statistical analysis in particular for the sound choice of proper cycles of equipment technical inspection and preventive maintenance.

EQUIPMENT COMPONENT CLASSIFICATION

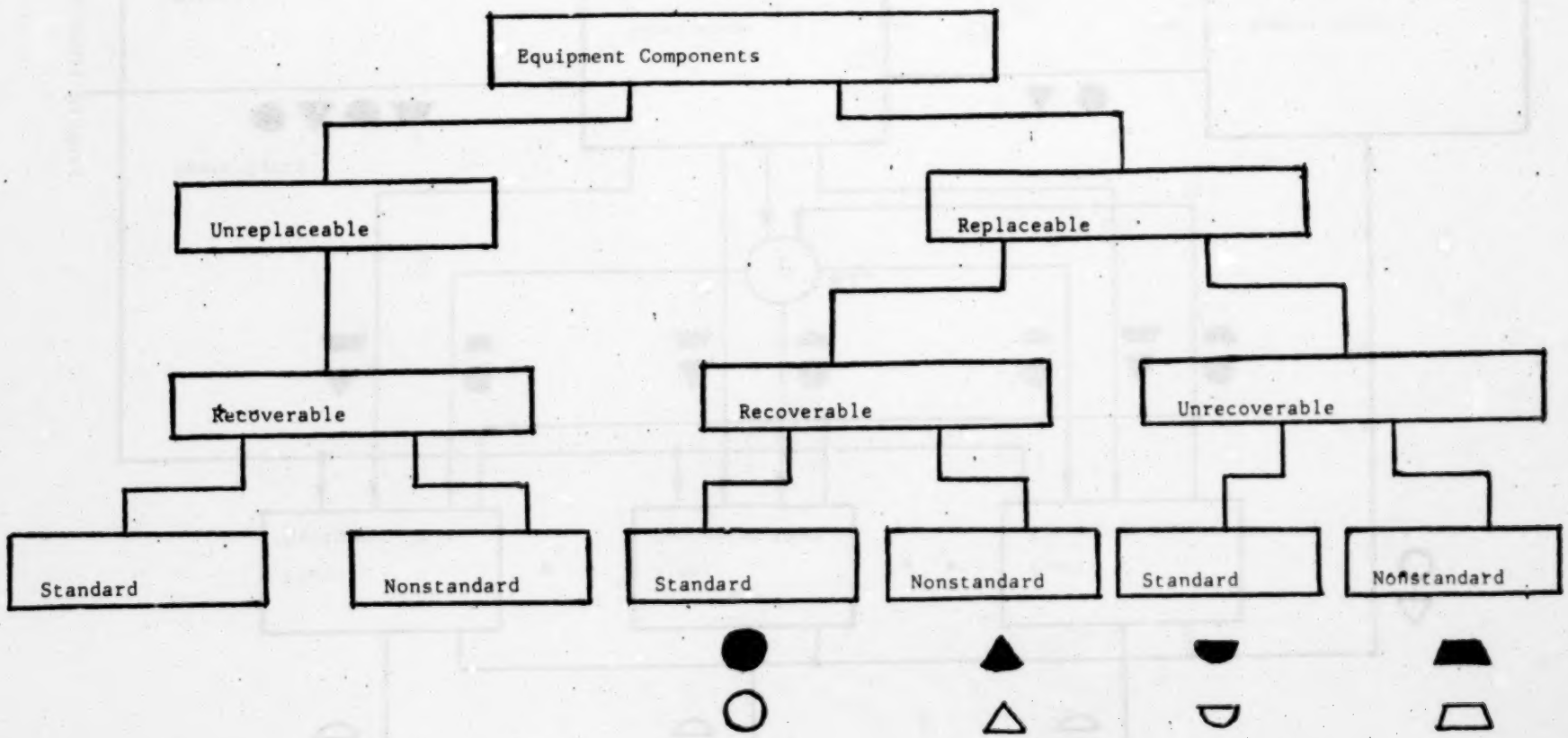
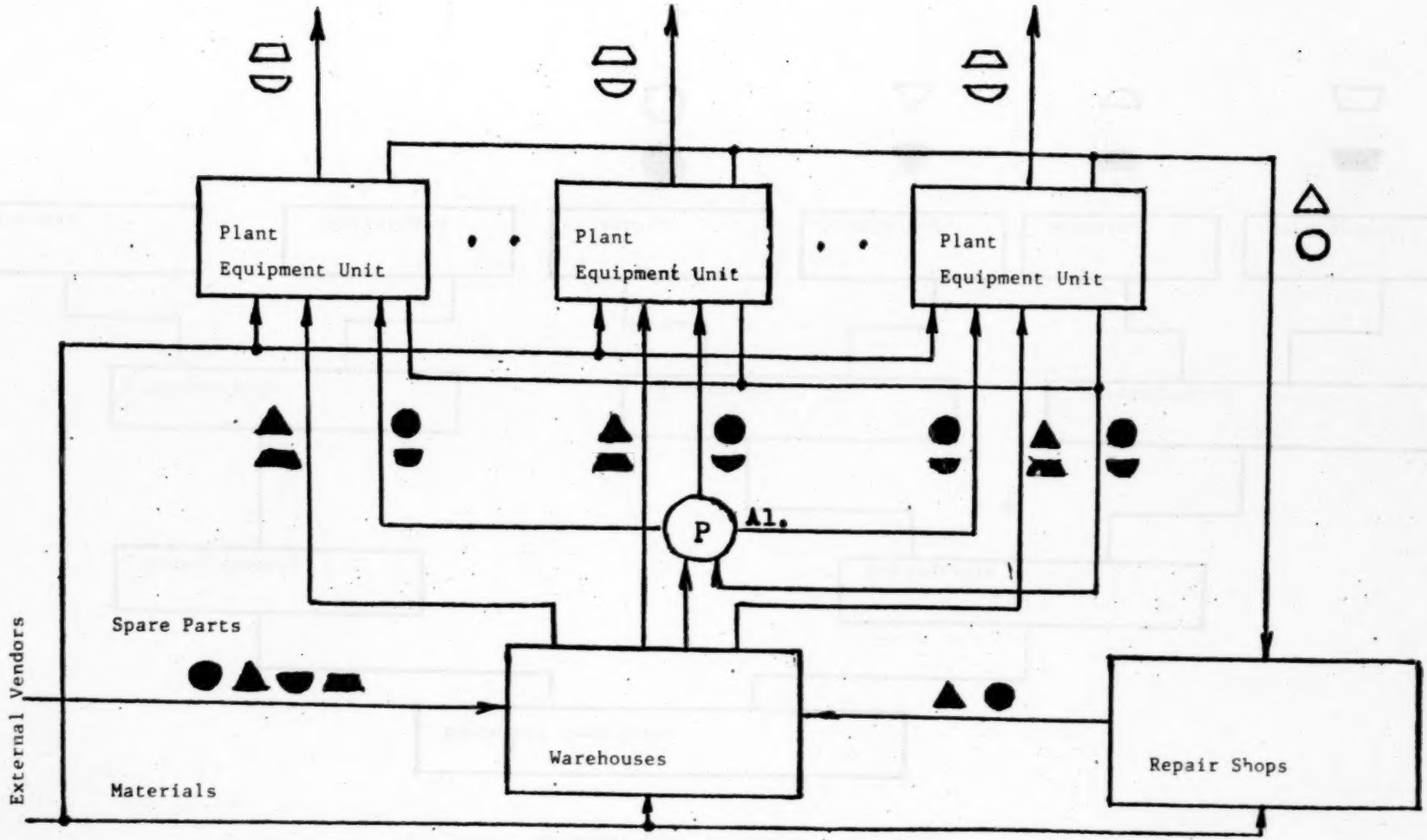


Fig. 1

EQUIPMENT COMPONENTS ROUTE



Difficulties of statistical data acquisition stem from the fact that failures of components occur rather seldom. And here standard components are in a better position as they are intensively used, and therefore a total flow of failures over the plant has a high rate that facilitates statistical evaluation.

To make this evaluation feasible it is necessary:

- to enter into the computer system failure data, identifying type and cause of failure with accuracy to a component of the equipment;
- to create a data base of such data and to execute their statistical processing.

3/ For replaceable standard recoverable components there exists a special problem of recording equipment components movement route.

Unrecoverable components are removed from an equipment in a case of wear-out or a failure. As with recoverable ones, they are routed after withdrawal to repair shops to be recovered, then go to a warehouse and finally are mounted into the equipment under repair.

Thus recoverable components perform cyclic relocations within a plant. A reliability of every component depends on its current cycle, while its availability for usage is defined by a certain phase of a cycle. This involves reporting of recoverable components movement. The problem is particularly important in connection with standard recoverable components in terms of their allocation to equipment items, since components in stock have to be allocated as well as those in the process.

4/ Controlled stores of standard components may include components in stock as well as reserve ones at production facilities.

Since it is necessary to provide a highly reliable performance of equipment items, reserve spare parts have to be available on the spot to remove quckly the failed components.

On the other hand, shutdowns of production equipment are not allowable on account of standard components stock-out, while they are available at some other equipment. Therefore, floor stock standard components may be allocated to different equipment items under repair as well as similar in-stock ones.

It is used to believe that standard components with discussed peculiarities take no more than 10 % of the volume of all spare parts both by nomenclature and by quantity. So these peculiarities are usually neglected in the CMMS development by their orientation primarily on the rest 90 % spare parts, i.e. on nonstandard components.

From our point of view, the role of standard spare parts in maintenance process is more serious than their relative volume, and it is precisely this fact which shows clearly the advantages of computer-aided maintenance management.

3. CMMS Functions Related to Equipment Standard Components

CMMS functions can be categorized into three areas of activity:

1/ "Equipment" area which includes testing and analysis of equipment condition, technical inspection control, and management of repair process.
2/ "Inventories" area which includes purchase orders releasing, control of spare parts receipts, as well as reporting and allocation of their on-hand inventories.

3/ "Production" area which includes process setup, production planning and reporting, and spare parts recovery.

The first area consists of 5 subsystems:

- Equipment Shutdown and Failure Accounting
- Equipment Units Movement Reporting
- Management of Equipment Technical Inspection
- Equipment Maintenance Planning
- Management of Equipment Maintenance

The second area consists of 3 subsystems:

- Release and Reporting of Spare Parts Purchase Orders
- Spare Parts Central Warehouse Control
- Spare Parts Inventory and Allocation

The third area includes 3 subsystems:

- Process Setup and Spare Parts Recovery
- Planning of Spare Parts Manufacturing and Recovery
- Decision Support Information System

Peculiarities of standard components control discussed in Section 1 are exposed within three subsystem of the first two areas.

3.1 Equipment Shutdown and Failure Accounting Subsystem

This subsystem of "Equipment" area performs two functions:

1/ Downtime and failure recording
2/ Statistical processing of failure data

The first function results in monthly reports of shutdowns and failures including cumulative daily data which are grouped due to production equipment items, failure categories, causes

of failure, etc. This is necessary for taking organizational and taechnical measures to improve equipment operation reliability.

The second function associated directly with standard components which, as mentioned in Section 2, give some opportunities for acqusition of sufficient data for statistical processing.

The subsystem of interest generates proper data file and calculates benefits as follows:

1/ Time interval between two successive failures
   /to define MTBF/
2/ Number of failures at a certain time period
   /to define a failure hazard rate/

The first parameter allows to establish equipment technical inspection and preventive maintenance cycles. Both parameters are used within three other subsystems of "Equipment" area. Technical inspection cycles become a background for development of proper weekly schedules with the indication of checking operations to be carried out by each inspector during the working shift.

Preventive maintenance cycles are used in a planning subsystem as a background of annual monthly maintenance schedules, which define due data and repair type for each equipment unit.

MTBF is used also in maintenance management subsystem to prepare operating instructions for a certain repair and to estimate spare parts requirements. These documents suppose a planned replacement of spare parts highly prone to failures.

The second parameter permits determination of a standard spare parts requirements per year and is used for calculation of their optimum inventory level.

The optimum inventory level becomes in its turn a basis for a release and accounting of replenishment orders within a proper subsystem of "Inventories" area. This subsystem performs spare parts purchasing on a basis of requirements of maintenance service. Conformably to nonstandard spare parts demand is defined by a repair schedule.

As with standard spare parts, another ordering policy can be applied here, namely the one based on inventory level control /see Section 2/. The lot size to be purchased in this case is defined by on-hand stock optimum inventory level.

To solve the above mentioned problems it is not sufficient to know expectances of all variables under consideration alone. For the minimization of emergency risk it is necessary to perform condition checking and replacement of unreliable components before its probability of failure becomes significant. Therefore, actually one has to deal with probability distribution and to solve a state estimation problem using small volume samples and arther sophisticated mathematical statistics techniques.

A numerical calculation of given parameters for specific equipment elements requires availability of input information that contains description of failures, their types and causes with an accuracy to a detail of equipment unit. This accuracy exceeds significantly the first subsystem requirements /shutdown and failure accounting requires an accuracy to a specific equipment unit/.

3.2 Equipment Units Movement Reporting Subsystem

This subsystem of "Equipment" area performs a function of replaceable standard element movements recording.

As mentioned in Section 2, each standard component of a given category can be in the following states:

1/ In the operation condition within the equipment
2/ In equipment unit on-site floor stock
3/ In a recovery process at a repair shop /this state may be further detailed according to the considered phases of recovery/
4/ In operational state at the varehouse

Components in states 2 to 4 form a stock available for allocation to different repairs. In this case components in states 2 and 3 require a prediction of transition time from those states to the state 4.

To make such an approach feasible the subsystem stores information on timing of mounting each component into the equipment /together with the definition of operating or reserve state/, as well as on timing of their removal. Information on recovery progress in a repair shop is delivered by the "Production" area and consists of the following components:

1/ Recovery setup progress messages from the Process Setup and Spare Parts Recocery subsystem
2/ Messages on due dates of recovery operations fulfillment from the production planning subsystem
3/ Messages on actual progress of recovery operations from the Decision Support Information System

The subsystem output data contain information on inventory levels and support decision making in their allocation to production equipment units to be repaired.

Equipment Units Movement Reporting subsystem belongs to "Equipment" area, although within "Inventories" area there exists a similar Spare Parts Inventory Accounting and Allocation subsystem, but the last concerns only the central

warehouse inventories.

As with considered "Equipment" area subsystem most of its controlled inventory is a floor stock of components at equipment units, so its basic allocation decisions involve transfer of components from one unit to another.

To make such specific decisions feasible each component at any state within a controlled plant must be supplied with a unique identification code. Nonstandard component item code indicates its position in a hierarchical structure "equipment - assembly - subassembly - ... - component". For a standard component that changes its location in the structure, such approach is not acceptable and other identifier is needed, without dependence on location within an equipment, for example, a sequential item number.

3.3 Spare Parts Inventory Accounting and Allocation Subsystem

This subsystem belongs to "Inventories" area and performs the following functions:

1/ Reporting of spare parts availability and movements
2/ Generation of data for stocking and allocation of spare parts inventory to users

The first function involves providing information on available inventory at a warehouse as well as receipts and issues of spare parts at or from stock for both nonstandard and standard ones.

The more interesting second function concerns only standard spare parts /see Section 2/ and becomes active as soon as warehouse receives user requisitions for spare parts delivery.

To make a reasonable decision on a lot size to be delivered to a given user one must take into consideration the following information:

1/ Available spare parts at a warehouse
2/ Anticipated delivery of spare parts by external or internal vendors /for purchased and manufactured by own repair shops components accordingly/
3/ Predicted spare parts usage both by a given and other users

The main management goal is timely and complete supply of required spare parts to all repairs indicated in user requisitions. Furthermore, the forecasts of spare parts usage by each equipment unit should be produced in a form of a maintenance schedule, indicating spare parts requirements for every specific repair.

Such on-demand policy of spare parts allocation involves inevitably their prior assignment /stocking/ to anticipated demand. The stocking may cover both on-hand and on-order inventories.

Receipts/issues data are available from the central spare parts warehouse information subsystem operating within "Inventories" area. On the other hand simultaneously forecast availability of purchased components from external vendors could be estimated according to planned and closed purchase orders. This information is available from Release and Reporting of Spare Parts Purchase Orders subsystem within the same area.

Forecast availability of spare parts produced by repair shops of the plant can be derived from production schedules generated by the spare parts production planning subsystem, and from actual manufacturing process data delivered by Decision Support Information Subsystem. Both subsystems belong to "Production" area.

The above mentioned forecast of spare parts usage is derived from a maintenance schedule generated by the Equipment Maintenance Planning subsystem, and from actual spare parts usage data generated by Equipment Maintenance Management Subsystem. Both of them belong to "Equipment" area.

It is interesting to note that a problem of standard spare parts stocking and allocation is quite the problem which combines practically all CMMS subsystems of three areas into a unified system referred to as Integrated Maintenance Management System. The similar integration is attained due to Equipment Units Movement Reporting Subsystem /see Subsection 3.2/, but not so much.

In the environment that excludes existence of the two subsystems all three areas can perform their functions independently, if operating personnel will generate spare parts purchase and manufacture orders. Consequently, Spare Parts Reporting and Allocation Subsystem may be treated as an integrating superstructure upon other CMMS subsystems.

4. Conclusions

This paper permits to make the following conclusions concerning techniques of problem solving for some problem areas of CMMS at steelworks:

1/ Equipment shutdown and failure data must be detailed to the level of a specific component of an equipment unit.
2/ Statistical data processing is necessary for a calculation of such parameters as MTBF and hazard rate for different equipment components.
3/ Standard recoverable components movement reporting must be carried out to generate information required by the problem of allocation these components to repairable equipment items.
4/ It is necessary to solve a problem of standard spare parts stocking and allocation to repairable equipment items.

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REPORT **

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Chapter	Description	Page
1.0	INTRODUCTION.....	3
2.0	CONCLUSIONS AND RECOMMENDATIONS OF THE EXPERT GROUP MEETING	5
3.0	SYNOPSIS OF THE REPORTS PRESENTED BY THE EXPERTS.....	8
4.0	DEVELOPMENT AND IMPLEMENTATION OF CMMS IN IRON AND STEEL INDUSTRIES IN DEVELOPING COUNTRIES: GUIDELINES AND RECOMMENDATIONS.....	14
5.0	DEVELOPMENT OF HUMAN RESOURCES.....	18
6.0	FOLLOW-UP ACTIVITIES OF COMPLETED PILOT PROJECTS.....	19

Annexes

I. List of participants

II. Programme and Schedule of the Meeting

INTRODUCTION

The First Expert Group Meeting (EGM) on Computerized Maintenance Management Systems (CMMS) in Metallurgy was organized by UNIDO in co-operation with INORGA Prague Institute, Czechoslovakia, from 28 January to 1 February 1985 with the following main objectives:

a) to examine the current situation and trends in development of CMMS in the Iron and Steel Industry in developing countries;

b) to identify the most effective way to develop and implement CMMS in the Iron and Steel Industry in developing countries;

c) to develop the practical recommendations and guidelines for implementation of CMMS in developing countries;

d) to discuss and determine the experiences in the development of human resources to support the application of CMMS;

e) to propose follow-up activities for completed pilot projects and effective forms of dissemination of know-how in the field.

The expert representatives of 13 countries (for complete list see Annex 1) attended the deliberations of the EGM. The EGM proceedings consisted of introductory presentation by UNIDO representative and five individual reports (optionally supported by other contributions) followed by plenary and individual discussions, consultations, plant industrial visits and excursions to technical laboratories; full EGM programme is given in Annex 2.

As the chairman of the EGM was elected Mr. B.S. Ramachandra (India). The discussions were monitored and final conclusions and recommendations were prepared by an elected working group consisting of UNIDO representative, B.R. Ramachandra (India), P. De Groote (Belgium), A. Kagramanov (USSR) and J.V. Krouzek (Czechoslovakia), the latter being also appointed as the EGM rapporteur.

The EGM papers were published by UNIDO under separate volumes and have been distributed to all participants. Their copies are available with the Metallurgical Section at the UNIDO Vienna Headquarters. Final conclusions and recommendations of the EGM are included in Chapter 2 of this Report. Chapter 3 then presents the short synopsis of the main reports for the purpose of an overall overview. To deal with specially highlighted problem areas during the EGM in more detail, Chapter 4 of the Report provides guidelines and recommendations of CMMS development and implementation in developing countries. The development of human resources is dealt with in Chapter 5 and the follow-up activities of completed CMMS pilot projects are outlined in Chapter 6.

CONCLUSIONS AND RECOMMENDATIONS

The EGM considers the problem of maintenance of plant and machinery and other capital assets of primary importance in all countries, in particular with utmost importance in developing countries - actual plant availability is usually considerably lower than that really required by the industry (in some cases actual plant utilization being 15-35% of the planned capacities), employing 30-40% of the company manpower, and contributing highly (25%) to the total manufacturing costs. In order to improve the status of maintenance, the EGM recommends an intensive action both on plants and as on a national and regional level to improve maintenance. The intensive action will comprise of the following:

1. A scheme of promotion of maintenance awareness in the industries should be formulated by UNDP/UNIDO and presented by the SIDFA to the respective Governments. This particular aspect should be part of a large industrial programme during the year of maintenance in developing countries as recommended in the Conference on Human Resources, Yaoundi, 1983.

2. Based on this promotion action, industries must be directed to introduce a sound and scientific maintenance organization comprising organizational structure, data collection methodology, planned maintenance and repair programmes, spare parts and maintenance materials procurement, manufacturing and usage control. The manning of the organizational structure should be corresponding with highly qualified and trained personnel.

3. A permanent expert working group should be constituted by UNIDO consisting of representatives of developing and developed countries and experts/consultants with large experience. This working group should periodically meet in order to analyse and discuss the status of maintenance in general and in particular the introduction and development of computer managed maintenance systems (CMMS) in the developing countries. They will formulate necessary and practical

corrective/improvement measures to bring up the maintenance status in concerned countries to a reasonable higher level.

4. The pattern of organizational structure having equal hierarchical level between maintenance and production is felt suitable. It is also felt by the expert group that the centralized maintenance system structure would give better results in achieving ultimately the implementation of CMMS in the industry vis-a-vis the mixed or decentralized structure.

5. Maintenance planning and management procedures should first be executed manually and automation should be gradually introduced. If main frame computer applications are already in operation, then a centralized CMMS can be more effectively introduced. If not, application of a distributed system following modularily step-by-step automation is recommended, starting with stores inventory accounting and control followed by the other logical steps, details of which are available in the Report.

6. The expert group considered that a lot of maintenance problems find their origin at the point of selection of equipment and supplies, during the project stage, where it was observed that the maintenance specialists are not associated. This is a matter of serious concern which has brought a crisis situation in the maintenance status in many developing countries. The expert group recommends the following action to prevent such situation in the future:

   a) associate systematically as a basic requirement, the maintenance specialists right from the project conception, contract negotiations, selection of supplier and equipment, follow-up from erection and commissioning;

   b) elaborate detailed specifications to be incorporated in the contract, concerning maintainability and reliability of equipment, plant standards, extensive technical documentation, manufacturing drawings of spare parts and components, designation, transport

handling, preservation and storage of spare parts, training of maintenance personnel, guaranteed supply of critical spare parts for a stipulated period along with a rational price escalation clause, extensions of technical assistance by the supplier as and where needs are according to well-defined requirements.

A purchase strategy on the Government level in developing countries should be formulated involving maintenance function which will cover the points brought out above.

7. Linking of condition based/predicative maintenance systems with appropriate instruments in usage on selected critical equipment complexes to this computer system can be done after stabilization of CMMS for a reasonable period. This is a sophistication in maintenance technique and technology which will result in better availability and reliability. The same holds for the use of of advanced mathematical modelling and Operational Research methods within the CMMS.

8. The concepts of CMMS, numerous functions and programme modules as well as guidelines for their implementations as introduced in iron and steel industries are applicable to other industries, in particular, the basic industries sector. The know-how and experience gained with CMMS in the iron and steel should therefore be effectively transferred to these basic industries.

9. The existing expertise in UNDP/UNIDO completed and/or on-going projects should be effectively shared through extensive promotion and publication of relevant information, establishment of national and regional technical consultancy and training centres par excellence for more formalized dissemination of know-how and the preparation and execution of similar CMMS oriented projects on both national and regional level to provide for more effective utilization of results and futher development in the field.

SYNOPSIS OF THE REPORTS PRESENTED BY THE EXPERTS

Introductory Presentation: Status of world iron and steel industry and UNIDO technical assistance in CMMS

by G.D. Surguchov, UNIDO

The introductory presentation consists of three parts. In the first part the status of world iron and steel industry and the prevailing trends in the steel production, materials and steel products flows (and their interdependency) are reviewed to provide the necessary background for the specialized topics of the EGM - the development and implementation of CMMS.

In the second part the role of UNIDO, its objectives, structure, technical assistance and projects' implementation are dealt with, in particular the activities of the Division of Industrial Operations and Metallurgical Industries Section are described, the organization of expert group meetings being one example of the transfer of know-how and exchange of experiences' activities.

The third part is concerned with the specialized topic of the EGM - CMMS. The justification and results of the completed, on-going and pipeline CMMS projects are being discussed, using as illustrative examples the developments of these types of projects in Czechoslovakia and Egypt, respectivelly. It is shown that the process of transfer of know-how from completed projects leads to the establishment of national and/ or regional training and consultancy centers, these providing technical assistance to other basic industrial sectors. The feasibility of these concepts and other fundamental problems in the field of CMMS development to be answered by the EGM panel are dealt with in the concluding part of the paper.

Report 1: Maintenance functions and organization structure of modern managed maintenance systems

by J.V. Krouzek

In the introduction a brief overview of Czechoslovak UNDP/UNIDO project on computerized maintenance in iron and steel industry is outlined. The successful implementation of the project is being shown using high benefits' figures of 63 million CS Crowns (approximately 5.3 mil. US $) stemming from project savings due to lower inventories, increased productivity and availability of both production and maintenance resources.

Maintenance functions and activities together with maintenance organizational structure and factors, influencing maintenance department organization are described; based on these general maintenance functions the major subsystems of modern CMMS are outlined and described, including the CMMS integrating elements and software support functions.

Evaluation of multiple aspects of CMMS development and implementation is then given with the recommendations regarding system step-by-step development and implementation, system modularity and integrity, modern interactive design and documentation techniques, hardware and software support and the development of human resources.

In the final part of the Report the dissemination of know-how activities upon the completion of the pilot CMMS project are dealt with, in particular the Czechoslovak follow-up UNDP/UNIDO projects introducing the centralized consultancy and training programme and giving the ground to the establishment of a National Technical Consultancy and Training Centre (NTCTC) for computer systems in maintenance and production in basic industries. The Report is concluded by the summary of experiences in the transfer of know-how process on international level under the UNDP/UNIDO auspices and TCDC schemes.

Report 2: Maintenance services in developing countries

by P. De Groote

In the first, introductory part, the major industrial maintenance problems in developing countries are featured, showing how critical the situation in this area is. The overview of the general principles of maintenance field services in the iron and steel industry follows, depicting also the organization of maintenance department in a steelplant, in particular the central maintenance support office, the mechanical and electrical divisions, the instrumentation division, central maintenance workshops and spare parts management and stores.

In the next part of the Report the problems in the design, supply, erection and commissioning of equipment for the new plant are treated, emphasizing the importance of sound planning, purchasing, constructing and installation for the future operation and maintenance of the new plant. Technical documentation objectives, contents and delivery, together with various systems of coding of equipment and spare parts are then described. Problems of rehabilitation of the production facilities and replacement of parts, assemblies and subassemblies are briefly summarized.

The final part of the Report is devoted to the operation of preventive maintenance including lubrication, testing and inspection procedures with illustrative examples. Throughout the Report, case studies of specific examples of the above problems in various developing countries are given.

Report 3: Computer based preventive maintenance system development and implementation experience in Egypt

by D. Tantawy

In the first part of the Report the critical role of maintenance to the industrialization of developing countries is stated and the

corresponding growth of maintenance planning and organization with specific maintenance problems in Egyptian Iron and Steel Company is shown, the UNDP/UNIDO projects for CMMS being the answer to these pressing problems.

One of the major parts of CMMS implemented in EISCo under UNDP/UNIDO project was the preventive maintenance and planned repairs system which enables to reduce most effectively down-time and maintenance costs, prolonged the life time of equipment and helped in the standardization on the plant level (thus also reducing the production costs).

The planning of maintenance, workshop scheduling and inventory control systems are described in full detail showing necessary procedures, input data, output listings, documentation used, coding systems, implementation steps and numerous practical methods and hints for both manual and computer based systems.

The sequence of UNDP/UNIDO technical assistance projects is also briefly discussed, showing the implementation phases and their progress from single project on CMMS to other projects in production planning, material tracking and process control as well as the preparation of plans for African regional centre par excellence in metallurgical and engineering industries (to provide for the transfer of know-how process).

Report 4: Development and implementation of computerized managed maintenance systems - VOEST ALPINE experience

by E. Reichel and W. Pilz

In the introductory part of the Report the VOEST ALPINE group, its metallurgical plants, organization of maintenance activities and their automation are thoroughly described.

The main body of the Report is devoted to the case study examples - the computerized system for planning and control of central maintenance workshop in VOEST ALPINE Donawitz and other works and the planned

maintenance systems installed in ZISCO, Zimbabwe and BAYOU, USA. For the Donawitz works the standard software PS package was implemented with the following modules: order handling, bill of material processing, preparation of job plans, preparation of shop floor documents, machine centers work assignment, shopfloor control and production reporting, cost control. The individual modules are briefly described as well as the project schedule, benefits and the hardware support. In a similar way the maintenance systems in Linz and Liezen VOEST ALPINE works and ZISCO and BAYOU companies are described. The interesting feature of these systems being the effective use of microcomputer hardware support. The maintenance system package comprises of the servicing, inspection and reporting modules with optional central workshop order preparation, spare parts ordering and personnel capacity planning.

The role of microcomputers is specially highlighted in the Report dealing with microcomputer condition monitoring, maintenance performance measuring and microcomputer networks; the last part of the Report is then devoted to the VOEST ALPINE industrial services technical assistance programme, especially in the maintenance area.

Report 5: Some special issues of designing computer-aided management information system for steel works maintenance services

by A. Kagramanov

The Report describes experiences with the application of computers to maintenance management and operations in USSR, in particular, the most critical area considered - the supply of standard spare parts, assemblies and subassemblies for main production facilities.

The equipment components are classified depending on their possibilities to be replaced, reconditioned and standardized. Behavioral peculiarities of equipment standard components are then treated in full detail covering inventory management, production equipment state reporting and analysis and recording of equipment component movement routes. For these problem areas the corresponding CMMS functions/ subsystems are described, i.e. Spare parts inventory accounting and allocation subsystem, Equipment shutdown and failure accounting subsystem and Equipment units movement reporting subsystem.

In the conclusions of the Report it is shown that the Spare parts reporting and allocating subsystem can provide an integrating superstructure upon other CMMS subsystems, the availability of statistical data for equipment shutdown and failure, components movements and spare parts standardization being the most important prerequisites for the overall CMMS implementation.

DEVELOPMENT AND IMPLEMENTATION OF CMMS IN IRON AND STEEL INDUSTRIES IN DEVELOPING COUNTRIES: GUIDELINES AND RECOMMENDATIONS

The EGM considers that there is a need for CMMS in the iron and steel industries in developing countries. Before introduction of CMMS in developing countries one should take into account the following pre-conditions:

- Good functioning organizational structure, i.e.
  - organizational chart
  - data collection and evaluation methodology
  - planned maintenance and repair programmes
  - well-trained personnel;
- Complete and adequate technical documentation concerning the equipment;
- Codification methodology for equipment and spare parts;
- Master spare parts accounting system.

Computerization can then be done after a certain reasonable period of successful working of the manual system, through a logical step-by-step approach:

- Step 1: Spares and maintenance material inventory accounting and control.
- Step 2: Work order for job execution including breakdown request and reporting.
- Step 3: Equipment and maintenance monitoring.
- Step 4: Job plans, preventive maintenance and repair schedule.

- Step 5: Performance analysis and evaluation of status of equipment condition vis-a-vis planned.
- Step 6: Update preventive maintenance and repair schedules in reference to the analysis of equipment condition.
- Step 7: Estimate of manpower required, jobwise and catalog of jobs.

To introduce a CMMS in an existing plant one should make a differentiation between two situations:

- Plant is already equipped with mainframe central computer. The unused capacity could be used for step-by-step extension to CMMS application.
- Plant has no mainframe computer application wherein one may adopt a centralized or distributed system approach following modularly step-by-step automation and integration.

The introduction of CMMS could first be done in a pilot production area of a large-scale pilot plant and then be extended to other production areas of the plant. This experience would also allow to develop CMMS for medium small-scale plant. Iron and steel industries in developing countries would be the best suited nucleus for this pilot plant and extension to other industries.

General functional structure of CMMS based on the basic maintenance functions and organizational structure of maintenance may include the following functions:

1) Inventory and Stores Management:

- spare parts catalog
- inventory record keeping
- inventory control
- parts and materials allocation
- disbursement

2) Purchasing of Spares, Materials and Services:

- purchase requisition
- purchase order generation
- vendor data update
- follow-up

3) Maintenance Work Order Creation:

- job requests
- verification and work order generation
- dispatching

4) Maintenance Planning:

- plant catalog
- preventive maintenance planning
- repair planning
- equipment lay-offs planning
- material requirements planning
- manpower requirements planning
- maintenance cost planning

5) Spare Parts Manufacture and Reconditioning:

- drawings
- bills of material
- routing operation
- work centres
- capacity planning and operation scheduling
- shop floor monitoring and control

6) Maintenance Work Order Scheduling:

- job selection
- CPA method application
- capacity planning and job scheduling
- releasing maintenance jobs
- dispatching
- rescheduling

7) Maintenance Work Order Monitoring:

- equipment lay-offs monitoring
- maintenance order monitoring
- job status reporting
- manpower loading and efficiency
- maintenance cost monitoring

8) History and Analysis:

- job completion reporting
- maintenance cost analysis
- equipment analysis
- preventive maintenance and planned repair cycles and standards development

9) System Software Support Function:

- data bank and coding system for the above described application functions
- teleprocessing network system and on-line interactive enquiry support depending on the centralized/distributed processing approach
- application transactions support
- computer operating system and associated housekeeping programmes.

The CMMS design, development and implementation will be essentially speeded up through the introduction of software for interactive system design, computerized documentation and interactive programme testing and development.

The problem of suitable computer hardware to support CMMS functions application, choise of centralized/distributed system concept and other specific aspects, e.g. licencing, leasing policies, engineering services, minimum configuration technical parameters should be one of the tasks to be developed by the Maintenance Working Group in UNIDO as recommended by this EGM.

DEVELOPMENT OF HUMAN RESOURCES

Development of human resources to support the application of modern managed maintenance systems should be based on an essentially practical approach in the following fields:

- Technical documentation
- Preventive maintenance and lubrication programmes
- Job preparation
- Maintenance data collection and evaluation methodology
- Inspection
- Stores inventory accounting
- Instructions for end users of CMMS
- Software development of CMMS with system analysts and designers and application and systems programmers

Human resources should be developed using the various forms of expert working group and consultancy meetings on regular basis, specialized seminars, study tours and demonstrations, fellowships, expert and consultancy services.

The importance of extension of existing projects in the field of maintenance should be stressed in order to transfer the acquired experience and capacities to other industries of the country or region concerned. This could be in the form of periodically repeated training programmes and should be one of the tasks to be developed by the Maintenance Working Group in UNIDO as recommended above.

FOLLOW-UP OF COMPLETED PILOT PROJECTS AND DISSEMINATION OF KNOW-HOW

There is a need for better integration and co-ordination in the matter of know-how expertise and resources accummulated at UNDP/UNIDO with implementation and completion of CMMS projects in developing countries. The achievements and successful results of the completed CMMS projects in the Arab Republic of Egypt (DP/EGY/81/012) and Czechoslovakia (DP/CZE/77/005) need extensive promotion through publication of relevant information to bring home the awareness of advantages to developing countries. This process should be in conformity with conclusions of the Third UNIDO Consultation at Caracas in 1982, particularly concerning transfer of know-how/expertises.

The existing project in Czechoslovakia for the establishment of a National Technical Consultancy and Training Centre and a similar project under preparation in the Arab Republic of Egypt on the regional level should provide the ground for preparation, development and implementation of CMMS projects in other developing countries, using the forums mentioned in Chapter 5. These projects should be considered as a regional nucleus for TCDC and extended to the centres of excellence. To achieve the objective, existing expertise in UNIDO projects in other countries should also be utilized.

ANNEX I

LIST OF PARTICIPANTS

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ANNEX 2

EXPERT GROUP MEETING-PROGRAMME AND SCHEDULE SUMMARY

Prague, 28 January - 1 February 1985
Hotel accommodation: IH Internacional, Praha 6, nam. Druzby 1
Meeting place: IH Internacional, conference premises on 10th floor
Secretarial/information services: EGM secretarial, room No. 225

January 28
Monday

08.30-09.00	EGM opening
09.00-10.00	Introductory presentation: EGM objectives and UNIDO technical assistance to developing countries (Senior Industrial Development Officer, UNIDO)
10.00-12.00	Report 1: Maintenance functions and organizational structure of modern managed maintenance systems, overview of major subsystems and integrating elements and evaluation of the multiple aspects of implementation of computerized maintenance systems, including hardware, software and resources and follow-up activities in the dissemination of know-how (using case study - practical example of Czechoslovak UNDP/UNIDO pilot project implementation) (Mr. Krouzek - INORGA Prague, Czechoslovakia)
13.30-14.30	Co-paper A: Experience of implementation and use of computerized maintenance system in East Slovakian Steelworks, Kosice (Mr. Bilicka - East Slovakian Steelworks, Kosice, Czechoslovakia)

14.30-17.30	Report 2: Maintenance field services, various types of systems used for the planning, installation and documentation and coding of equipments and spare parts, rehabilitation of facilities, replacement of parts/assemblies and preventive maintenance operation, incl. lubrication, testing and inspection using case studies of specific examples in various developing countries (Mr. De Groote - Belgium)

January 29
Tuesday

08.30-10.30	Report 3: Computer based preventive maintenance system - development and implementation experience in ARE, incl. the evaluation of benefits in both performance/ productivity and financial areas (using a case study example of UNDP/UNIDO project implementation in EISCo, ARE) (Mr. Tantawi - ARE)
11.00-12.00	Co-paper B: Data base for maintenance management systems on personal computer (Mr. Toth - INORGA Kosice, Czechoslovakia)
13.30-16.30	Report 4: Development and implementation of maintenance planning and scheduling and monitoring systems for maintenance and repair shop and field activities (using a case study of VOEST ALPINE experience for various plants in both industrially developed

	and developing countries) (Mr. Reichel - Austria)
17.30-18.30	Evening discussion and personal computers demonstration
January 30 Wednesday	
08.30-10.30	Report 5: Spare parts and assemblies repair and reconditioning and manufacture, purchasing, stocking and inventory control systems, incl. costing and budgeting and the application of mathematical modelling (using examples from metallurgical plants with centrally planned economics) (Mr. Kagramanov - USSR)
11.00-12.00	Co-paper C: Use of microprocessors for equipment maintenance diagnostics (Mr. Smolik - INORGA Prague, Czechoslovakia)
13.30-16.00	Visit of INORGA experimental laboratory
16.00-18.30	Election of the working group for the preparation of final report and recommendations
January 31 Thursday	
05.30-06.00	Transfer to Prague airport

	Visit of East Slovakian Steelworks, Kosice - plants, pilot implementation, terminal clusters and the computer centre and follow-up discussions
19.00-21.30	Meeting of the working group
February 1 Friday	
08.30-12.00	a) Final meeting of the working group
13.30-15.00	Final plenary discussions
15.00-17.30	Presentation and approval of recommendations